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Service volume and other factors affecting the costs of immunizations in the Gambia

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The total cost of the Expanded Programme on Immunization and of its various components in the Gambia over a period of one year (from July 1980 to June 1981) was investigated, and the costs per immunization dose and per fully immunized child were calculated. The total costs were to a large extent (45%) due to the cost of personnel and fixed costs. Where there was efficient delivery of immunizations, the average cost per dose was about one-fifth of that in the most costly facilities (range: US$2.32 to $0.41). The lower costs were related to more intensive use of the facilities. The national average cost was $1.09. The implications of the results of this study for policies to reduce costs are discussed, and further areas of research are suggested that will provide improved information to guide decision-makers in the use of scarce immunization programme resources for better health in the world.

Major studies of immunization costs have been carried out in Indonesia, Philippines and Thailand by Creese and associates (*1–3*),[a] but some other case studies are also available (*4–6*). Although all the programmes studied come under WHO's Expanded Programme on Immunization (EPI), the specific immunizations vary from one country to another; most countries provide fewer vaccines than are available through the comprehensive programme in the Gambia.

The economic and other aspects of the immunization programme in the Gambia have been studied in the past, notably in the report by Foege on measles and other disease control programmes (*7*), and an internal/external evaluation of the Gambian immunization programme (excluding the costs) that was carried out in 1980 (*8*). The present paper describes the principal findings of a study on the cost of immunizations provided in a year through the WHO-supported Expanded Programme on Immunization in the Gambia (*9*), and considers the priority needs for future studies.

MATERIALS AND METHODS

In 1982 an external multidisciplinary team spent about 15 days in the Gambia working with local counterparts on a complete study of the national EPI. The recommended immunizations included 4 doses of DPT and polio vaccines (including a booster), and single doses of BCG, measles and yellow fever vaccines. Four doses of tetanus toxoid were recommended for women. The immunization programme was integrated with the maternal and child health programme, and combined services were delivered by teams that worked full-time on certain days at fixed bases, and on other days travelled to outlying villages or health posts on regular schedules.

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[a] CREESE, A.L. *Expanded Programme on Immunization: costing guidelines.* Unpublished WHO document, EPI/GEN/79.5, 1979.

The costs of one full year of activity, from July 1980 till June 1981, were estimated for a sample of 13 field units or sites covering a variety of situations; appropriate allocations of costs from the central level were made to these field units. National level data and local delivery costs, after extrapolation to cover the full country, yielded the total cost of the national programme. Estimates included the cost of all the resources used, whether supplied by the Gambian Government or by external organizations. A notable contribution by the latter included the services of two expatriate professionals. The results of the 1981 cluster surveys conducted by the Gambian EPI staff, which yielded important information on the coverage of each type of immunization, were also taken into consideration.

In examination of the data, the total annual cost of the Gambian EPI was first analysed in separate cost profiles or distributions by categories (personnel, equipment, and so forth). The categories were grouped into two parts, fixed and variable costs, based on whether the cost changed as the volume of services (e.g., the number of immunization doses) changed. A profile was made for the total national programme and for each of the 13 field units.

The *average cost* of the overall programme was indicated by the cost per dose, i.e., the total cost divided by the total number of immunization doses given. An immunization dose was defined as a single vaccine administration, whether given by injection or by mouth. In the case of DPT (diphtheria, pertussis, tetanus), the three antigens were administered simultaneously in one dose.

Programme coverage can be measured in a variety of ways. When based on the doses of vaccines received, it might be summed up in terms of "fully immunized" status—that is, those persons who received all the requisite doses. In this study we have followed the WHO guidelines that refer to the cost per *fully immunized child* (*3*), but have devoted less attention to cost-coverage values than to basic cost estimates.

RESULTS

Cost profiles

The total cost of the national programme was about US$375 000 in the 1980–81 study year, exclusive of the US$225 000 for expatriate personnel (Table 1). The cost per capita amounts to about $0.64, based on an estimated 1979 population of 584 505. Including the cost of the expatriates, the per capita cost is approximately $1.00. It seems justifiable, for purposes of international comparisons of similar programmes and for more realistic estimates of future EPI costs in the Gambia, to exclude such expatriate costs, which were incurred mainly in order to initiate the activities concerned with programme administration and epidemiology.

Table 1. Cost profile of full national EPI of the Gambia, including central costs and extrapolated local (field unit) costs, from 1 July 1980 to 30 June 1981[a]

	Amount (US$)	Percentage
Variable costs:		
Personnel (local)	141 007	37.6
Supplies (central)	35 041	9.4
Vaccines (central)	44 741	12.0
Transport: operation/ maintenance (local)	41 499	11.0
Subtotal	262 288	70.0
Fixed costs:		
Personnel (central)	25 785	6.9
Transport: operation/ maintenance (central)	14 899	4.0
Buildings:		
central	2 503	0.7
local	6 310	1.7
Equipment:		
central	5 771	1.5
local	46 673	12.4
Training (central)	10 535	2.8
Subtotal	112 476	30.0
Total	374 764	

[a] Cost in US dollars, converted from dalasi; the exchange rate at the middle of the study period was Dl. 678 = US$1.00.
"Central" refers to the national headquarters level.
"Local" refers to the field unit level.
Costs of expatriate personnel (totalling US$225 362) are omitted.

(*Sources:* Gambian EPI headquarters records; EPI staff; data collected by the study team at selected field units; and study team estimates.)

Table 1 shows that the cost of personnel, without inclusion of the expatriates, was nearly 45% of the total cost. The next most costly items were the operation and maintenance of transport services, equipment, and vaccines; none of these categories individually exceeded 15% of the total cost. Much less (2–3%) was spent on the buildings; in the Gambia, immunizations and other basic health services are provided in unpretentious quarters.

Cost profiles were also compiled by the study team for the 13 field units for delivery of immunizations, and they included allocations from the total (national

level) costs to the specific localities. These profiles (not included in this article) were roughly similar to the cost profile for the nation as a whole; the personnel costs were always highest, except in four areas where more was spent on equipment or vaccine requirements. Field units with less activity, indicated by a low average number of immunizations per service session, tended to have a higher proportion of the total cost spent on personnel. The operation and maintenance of transport services always exceeded 10% of the total cost in the field units but was never very high, even where the team had to trek to relatively distant sites. The building costs were remarkably low.

Cost per dose

The national average cost per immunization dose was $1.09 (excluding expatriate costs) or $1.75 (including them). This type of cost measurement is basic to other computations made in the Gambian study—e.g., the cost per fully immunized child, which is the product of the cost per dose and the number of doses required for "fully immunized" status.

The average cost was also computed for each of the 13 field units and produced some interesting results which, together with the costs per fully immunized child, are presented in Table 2. The cost per fully immunized child is here presented both with and without taking into account the cost of yellow fever immunizations, which are not included in all national EPIs, but are important in the Gambia; these immunizations incurred about 9% of all costs. There was great variation among the field units in the cost per dose, which in general was inversely related to the annual average of the number of doses administered per session at each site; more intensive use of the facilities tended to lower the unit cost. This relationship is shown clearly in Fig. 1.

Cost in relation to programme coverage

As stated above, our indicator of programme coverage of the children is the cost per fully immunized child. Cluster sample survey information for each of three zones in the Gambia gave us the number of immunization doses necessary to achieve fully immunized status. The costs per fully immunized child (Table 2) show great variation among the 13

Table 2. Cost per immunization dose and per fully immunized child for selected individual field units and for the whole of the Gambia from 1 July 1980 to 30 June 1981[a]

Site (field unit)	Average no. of immunizations per session	Cost per immunization dose (US$)	Cost per fully immunized child (US$)	
			Including yellow fever vaccine	Excluding yellow fever vaccine
Brufut	44	2.32	36	26
Faraba Banta	46	1.95	30	22
Kerewan	61	1.61	26	21
Leman Street	63	1.20	18	14
N'Jaba Kunda	65	1.44	24	19
Fatoto	117	0.95	16	14
Bansang	120	0.81	14	11
Basse	157	0.92	16	13
Georgetown	161	0.90	15	13
Mansakonko	181	0.57	10	7
Kudang	227	0.47	8	6
Brikama	268	0.62	10	7
Brikama Ba	273	0.41	7	6
Whole country		1.09	18	14

[a] Cost in US dollars, excluding the cost of expatriate personnel, the inclusion of which would increase each cost item by 60%.

(*Sources*: EPI staff; EPI headquarters records and team estimates (for unit vaccine costs); data collected by the study team at the field units; and coverage cluster surveys of EPI staff (for the number of doses required for "fully immunized" status).)

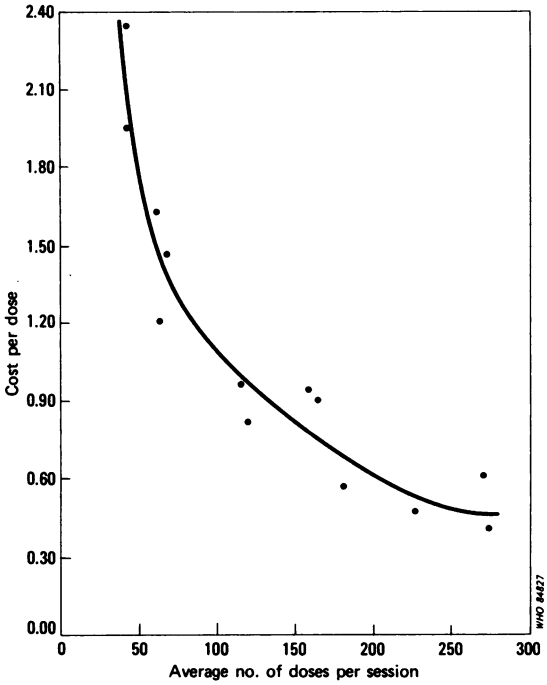

Fig. 1. Average cost in US dollars per dose, excluding cost of expatriate personnel, in relation to the average number of doses per session (service volume) for the 13 field units, from 1 July 1980 to 30 June 1981.

field units. Excluding the cost of yellow fever doses so that there will be better comparability with other countries, we find the costs for each field unit ranging from $6 to $26 per fully immunized child (overall national cost, $14). These values appear to be inversely related to the average number of doses per session.

DISCUSSION

The effect of service volume on cost

The service volume (or the number of immunization doses per session) at the 13 field units in this Gambian study appears to be the most important factor influencing the average cost per dose. In interpreting this influence, we must first consider some basic economic concepts concerning production costs.[b]

Good managers of health delivery units try to choose the combination of personnel (of various types), supplies, and other inputs that will minimize the costs for a given service volume, at the prevailing rates of pay and prices. When the total costs (of the cheapest combination) are divided by the service volume, an average cost function is derived. When presented in a graph (Fig. 2), the curve shows that the average cost first falls and then rises as the service volume increases—that is, as the existing delivery capacity is used more intensively, even beyond the optimum volume.[c]

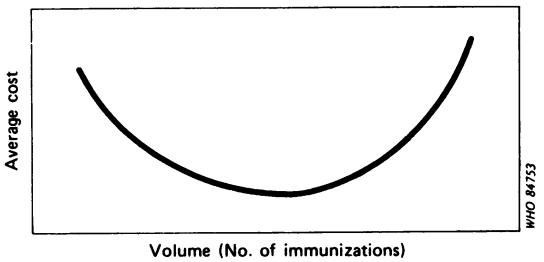

Fig. 2. Typical curve showing relationship between service volume (i.e., number of immunizations) and average cost.

Our findings of the costs in the Gambia show a clear inverse relationship between the average cost per dose and the service volume for the 13 field units providing comparable EPI services. It seems that the optimum service volume (corresponding to the lowest average cost) has not yet been reached in the field units because the average cost curve showed no trough throughout the range of service volumes studied. This result is consistent with the estimates made elsewhere by Creese and his associates who used the cost per fully immunized child (instead of the cost per dose) for their average cost (*1–3*).

A significant factor in this Gambian study appears to be the existence of substantial "fixed" costs connected with the delivery of immunizations over a year or other short period. As seen in Table 1, at least 30% (or 56% if the cost of expatriate personnel are included) of the total costs were fixed costs during the study year. The "fixed" resources included the central (national) headquarters overheads and the buildings and equipment in the field units. Of the variable costs in Table 1, some clearly changed with the service

[b] An introductory presentation of such concepts is described by Rapoport et al. (*10*).

[c] This cost-volume relationship should be distinguished from a different set of forces affecting average costs that are analysed by economists under the heading of "economies of scale." These refer to cost reductions that accompany expanded (instead of the same) service facilities, such as larger buildings and new specialized equipment or personnel. Data available for our study, like most health programme analyses, are not sufficient to permit a direct assessment of the existence of, or lack of, economies of scale. The most that can be said is that there is no apparent association between the Gambian delivery unit size (scale) and the cost per dose. For more details, see reference *10*.

[d] Different views on this matter can be found in the literature of health care costs. We followed Creese et al. (*3*), but other sources have regarded local personnel costs as fixed.

volume; the cost of vaccines is the best example of this. It is possible that we might have misplaced the local personnel costs in the variable category.[d] If all these were assumed instead to be fixed, the fixed share of the total costs would increase to 68%, reinforcing the decline in average costs with volume. In any case, a substantial portion of the resources required for the EPI changes little (if at all) in cost as the volume increases or decreases. Under these conditions, therefore, the results (Table 2 and Fig. 1), as expected, show that up to a certain high level of utilization of resources, the delivery of a larger number of immunization doses tends to reduce the average cost. However, there must be some point beyond which a higher delivery is accompanied by inefficient utilization of resources, which raises the average cost, but this point does not appear to have been reached in any of the 13 field units in our sample.

Other possible explanations of findings

Possible alternative explanations, like several cited by Creese et al. (*3*), do not seem to apply to the Gambian EPI situation. For example, changes in the type or composition of resource inputs in the immunization programme could influence the costs. In the Gambia, however, the same vaccines are delivered through a single system—EPI integrated with maternal and child health services (MCH), under common national supervision. Moreover, no important differences in the composition of the service teams were observed during our study. Major variations in prices paid for the resources to provide immunizations, including staff salaries, might explain the cost differences in some countries but not in the Gambia, where wage rates are standardized through all grades for public health personnel in all parts of the country. The prices of other resources, including vaccines, also did not vary within the country.

The target populations to receive the immunizations can also differ in many ways. Any of several sociodemographic characteristics could affect their utilization of EPI services, which in turn will affect the number of immunizations given and the use of resources at the delivery sites. These factors have been noted in other countries (*3*), but their relevance in the Gambia is uncertain. The local populations certainly show ethnic and other differences around the country, and there are variations in population distribution within catchment areas. Any systematic relationship between these differences and the costs has yet to be demonstrated.

Policy implications

Our major finding of a relationship between service volume and average cost, through a fivefold range of differences in the field units' costs per immunization dose (from $0.41 to $2.32), and the analysis of explanatory factors given above have implications for cost reduction policies that could be considered not only by the Gambian public health authorities but also by officials in other countries with similar immunization programmes.

Our results suggest that increasing the volume of immunizations in those field units that dispensed relatively few doses per session or more intensive use of the existing facilities would lower the average cost. Procedures are available for estimating the degree to which changes, over a period of time, in the average cost of a field unit are related to utilization volume. In the Gambia, the already high coverage rate of a relatively small population imposes a limitation on further volume increases at most sites. Economies, however, might be made by more intensive use of staff (and other resources) because it was shown that a relatively large percentage of the total cost was attributable to personnel, which may be an indication of underutilization of staff in some places. Perhaps national level EPI administrators can find incentives for local managers and their staff to achieve some improvements in this direction.

Another possibility is to reduce the frequency of EPI sessions in certain areas so that each session could be used more intensively and efficiently. There may well be some administrative problems, especially in revising the schedules for the various types of clinics (e.g., established field units or temporary clinics set up in remote places after trekking), as well as reduced contact of patients with the immunization programme, leading perhaps to less coverage and generally weakened service outreach. This is a change to be made selectively—at only a very few sites—if at all.

Alternatively, there could be a redistribution of the catchment areas for some field units with a discontinuation of others. While this strategy aims at reducing the average costs through spreading the fixed costs over a wider area and increasing the number of immunization doses, it may present considerable problems and the overall merits are by no means certain. A major concern is the impact on patients, because the change would impose higher travel costs on some persons and perhaps a longer waiting (and travelling) time. The resulting discouragement to utilization of these services cannot be ignored. This policy might have adverse implications for the very successful outreach of the Gambian public health services, as some reduction of effective contact with the population could result from an increase in the size of the catchment areas. Furthermore, an integrated EPI/MCH service must be considered for countries like the Gambia. We suspect that clinics that

provide only small numbers of immunizations also take care of few MCH patients, and that policies to reduce the EPI costs will also improve the efficiency of the maternal and child health services.

To the degree that each field unit's "fixed" costs can be made "variable", or altered in response to changing service volumes, the average costs can be contained. We cannot expect to change the EPI's buildings or equipment in a short time; the national level staff and transportation costs also probably cannot be altered much, and are not large in the Gambia. The issue, then, is reduced to the health system's capacity to vary the number of local service personnel in order to make the EPI more cost-effective. Unfortunately, it is doubtful that much flexibility in staffing of the particular units can be achieved within a few months. Perhaps some personnel can be transferred from slower, high-cost units to busier, more efficient sites, but even that is limited by the need to continue to offer services other than immunizations. In general, staffing patterns for health service delivery, despite wide variations among them internationally or even within the same country, are notoriously difficult to change. This administrative constraint is likely to extend to attempts to substitute community-based health auxiliaries for more highly paid staff members within any short period.

An alternative EPI delivery pattern that might be considered, in view of the large proportion of costs for staffing and the disadvantage of distant treks for delivering immunizations, is the greater use of outreach facilities staffed by auxiliary personnel; if provided with cold chain equipment, vaccination supplies, and vaccines, existing personnel could administer the vaccines on a routine basis. The costs attributable to salaries and transport would probably be reduced, while those for cold chain equipment and vaccines (because of higher wastage) would be increased. Total costs might well be less than for the current system.

In summary, while it is clear that high fixed costs and low service volumes are responsible for high average costs in certain field units in the Gambia, solutions for promoting economies and efficiency are not easily adopted. Almost any proposal for cost saving, whatever its other characteristics, will pose challenges to EPI administrators. Such improvements in the use of scarce resources (and funds) can contribute to improvements in health status of all the people.

Priority needs for additional studies

Our work in the Gambia and other studies elsewhere in the developing world have provided useful information on the costs of immunizations, especially those organized under WHO's Expanded Programme on Immunization. The basis now exists for conducting comparative studies of EPI programmes in various countries, like the one already published (*3*). More work needs to be carried out, especially to compare the results from several countries where EPI services operate in different ways, e.g., places where the programme is an integral part of the basic public health services (especially MCH), as in the Gambia, compared with places where it functions independently.

Other areas of research could be helpful in decision-making for these programmes. Closer consideration of the partly immunized status of children could provide useful results on costs in relation to programme coverage, supplementing the data on the costs per fully immunized child. Partial immunization would include the cases receiving only some, but not all, of the recommended doses of particular vaccines, e.g., children who do not complete a full three-dose schedule with DPT or polio vaccine may still gain substantial protection.

The last point suggests the need for studies on the outcomes or effects of partial immunizations related to specific diseases or vaccines. Combining the resulting data with cost values would permit certain cost-effectiveness analyses yielding such results as the cost per case prevented or per death averted. Work on this is already in progress, including studies of cost in relation to the effects of measles vaccination and immunization for polio. For discussion of the subject of costs in relation to outcomes, the reader is referred to a survey article by Creese & Henderson (*11*).

Yet another priority area of research is the comparison of national-level EPI costs, especially recurrent ones, with various indicators of financial capacity. The results of such a study will provide information to officials on the very important issue of affordability of programmes.

We believe that many of the research areas indicated above are likely to yield more benefits than the same amount of effort devoted to further refinement of health cost accounting. Nevertheless, some potentially important methodological issues in costing remain to be resolved. For example, how significant are the costs to patients of time spent on travel and in waiting to be served in relation to the full cost of EPI. Study of such questions would add markedly to the research effort required, and so they can be recommended only for special projects and not for regular programmes.

When more detailed cost data are needed in certain studies or topics, an analysis of the allocations of costs among several programmes or subprogrammes will be required, e.g., division of the costs of personnel, transport, and other resources used jointly by EPI and by other components such as MCH. Our treatment of this problem with the Gambian data was

by allocating to EPI its full proportion of shared costs and this is just one of several ways to proceed. One could regard EPI as a mere "add-on", incurring only incremental costs. Another approach would be to distribute the individual costs among several vaccines or types of immunizations within the EPI. For example, if the cost of measles vaccination alone is sought, then the relevant portion of the EPI costs must be determined and assigned to the measles subprogramme. This can be done in different ways. In the case of a country with a limited range of EPI operations, the cost of any expansion in activities (e.g., introduction of new types of immunization) might be measured in terms of the additional cost only, so that the new immunization will appear to be cheaper than if another method were used to estimate the cost. Research on this topic is now in progress.

Despite the need for further cost studies of national immunization programmes in various situations, let us acknowledge the accomplishments of the past. The already available cost estimates of EPI are clearly helping decision-makers, especially in the developing countries, to improve their immunization programmes and so bring better health to all their people.

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RÉSUMÉ

VOLUME DES SERVICES ET AUTRES FACTEURS AYANT UNE INCIDENCE SUR LE COÛT DES VACCINATIONS EN GAMBIE

L'article rend compte des méthodes, des résultats et des implications d'une étude sur les coûts des vaccinations pour une année (de juillet 1980 à juin 1981) effectuées dans le cadre du Programme élargi de vaccination (PEV) en Gambie. Des analyses antérieures du coût du PEV dans d'autres pays sont examinées brièvement et la méthodologie de l'étude gambienne est résumée.

Les résultats montrent qu'une forte proportion, environ 45%, du coût total du programme de vaccination est imputable au personnel, même une fois défalqué le coût du personnel non national affecté au programme. Il apparaît que le frais sont plus élevés pour les centres de vaccination mal utilisés, le coût par dose de vaccin étant 5 fois plus élevé que dans les centres les plus efficaces. Ces coûts vont de 0,41 dollar E.U. à 2,32 dollars, à rapprocher de la moyenne nationale qui est de 1,09 dollar E.U. par dose. Un volume de services plus élevé (davantage de vaccinations effectuées à chaque séance) conduit à une utilisation meilleure des frais fixes, qui sont importants, d'où une réduction du coût moyen par dose. L'étude de facteurs autres que le volume des services a permis de constater que leur influence sur le coût unitaire est moindre.

Le coût par enfant ayant reçu toutes les vaccinations, un indicateur qui ne donne pas entièrement satisfaction, atteint le chiffre moyen de 14 dollars E.U. pour l'ensemble du pays (intervalle de variation: de 6 dollars à 26 dollars). Il est inversement proportionnel au volume des services.

Les implications de ces résultats pour l'orientation tant des programmes de vaccination de Gambie que d'autres pays sont examinées. Il est notamment prévu de prendre des mesures administratives visant à assurer une utilisation plus intensive du personnel et autres ressources existant dans les centres à coût élevé et de procéder à des changements dans les zones de regroupement. Aucune décision de ce genre ne sera prise sans problèmes, mais certaines méritent d'être examinées dans l'intérêt d'une meilleure utilisation des maigres ressources disponibles pour promouvoir la santé mondiale.

Enfin, plusieurs études hautement prioritaires sont suggérées, dont les résultats devraient permettre aux administrateur du PEV d'obtenir des renseignements sur les aspects économiques des programmes de vaccination et d'en faire un meilleur usage. Certaines méthodes de calcul des prix pourraient être reconsidérées. En outre, des analyses de rentabilité portant sur des interventions sanitaires déterminées seraient précieuses pour les responsables du PEV.

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